

CHILDREN'S PRODUCTION AND UTILIZATION
OF A SELECTIVE ATTENTION STRATEGY:
EFFECTS OF WORKER CAPACITY

BY

JANET MOORE-BAXTER

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1986

Copyright 1988
by
Joan M. Mundy-Garvey

ACKNOWLEDGMENTS

A few simple words could never sum up the gratitude that I wish to express to my supervisory committee chairperson, Patricia Miller. She has thoughtfully guided my work and my research interests. She has always listened, allowed me to make my own choices, and steered me back on course when I began to venture too far. Most of all, she has taught me to be sure confident of my abilities and ideas.

Scott Miller has introduced a new sense of logic to me by always forcing me (usually in subtle ways) to justify and defend my questions and ideas. Additionally, he has always reacted calmly (very calmly) and positively to my many intrusions on his thoughts. Joe Fischer has provided many thoughtful comments on the design of my research, has been a model of constant enthusiasm, and has encouraged me to confront those terribly confusing and scary issues in the areas of selective attention and memory. Richard Briggs has been an invaluable resource in the area of teaching and has helped me to establish a strong base from which to grow as a teacher of psychology. James Higgins has patiently dealt with my questions concerning statistical issues, especially repeated-measures analyses. He has also been an exceptional teacher of statistics.

As for my fellow graduate students, they have always reminded me to focus on the light at the end of the tunnel. They have been true friends--especially Karel.

Finally, the one person who has been there from the beginning to the end of my graduate study with constant faith in my abilities is Robby, my husband. His belief in my work and dreams has been, and always will be, a source of strength.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGMENTS	iii
ABSTRACT	vii
CHAPTER	
I. INTRODUCTION	1
Review of the Literature	1
Strategy Production	2
Strategy Utilization	3
Processing Capacity	8
The Present Study	12
Summary of Hypotheses	18
II. METHOD	21
Subjects	22
Materials and Procedures	23
Selective Attention Session	23
Memory Capacity Session	24
Design	24
Coding and Scoring	25
Selective Attention	25
Memory Capacity	26
III. RESULTS	32
Memory Capacity	32
Memory Capacity and Spontaneous Strategy Use	34
Memory Capacity and Spontaneous Production of the Selective Strategy	38
Memory Capacity and Overall Type of Strategy Use	38
Memory Capacity and Selective Recall	40
Other Effects on Recall	40
Individual Capacity Measures and Selective Recall	42
Memory Capacity Composites and Selective Recall	43

IV. DISCUSSION	51
Summary of Results	51
Memory Capacity as a Predictor of Selective Recall	53
Memory Capacity as a Predictor of Spontaneous Strategy Use	60
Consistency among Memory Capacity Measures	64
APPENDIX	
A1. QUESTIONS	69
REFERENCES	70
BIOGRAPHICAL SKETCH	74

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

CHILDREN'S PRODUCTION AND UTILIZATION
OF A SELECTIVE ATTENTION STRATEGY:
EFFECTS OF SHORT-TERM MEMORY CAPACITY

By

Janet Rudy-Bansay

August, 1988

Chairman: Patricia K. Miller
Major Department: Psychology

Previous research suggests two phases in the development of the ability to use a strategy of selective attention. The first phase involves strategy production, whereas the second phase centers around strategy utilization--the ability to derive facilitative effects for subsequent cognitive processing (i.e., selective recall) following successful strategy production. In the present study individual differences in short-term memory capacity were examined as a factor in both the production and utilization of a strategy of selective attention. In one session 41 kindergartners and 42 third graders were given a selective attention task

in which the effortfulness of using the appropriate selective strategy was manipulated. During a study period on each trial, children chose which items (relevant or irrelevant) to expose to an apparatus with a 2 X 8 matrix of doors concealing each item. A task of recall for the location of relevant items followed. Spontaneous strategy use was observed in a baseline condition. Additionally, in two other within-subject conditions the effort of either searching or monitoring and monitoring the selective strategy was reduced (i.e., the child was instructed to use the strategy or the experimenter opened only relevant doors). These manipulations to reduce the effortfulness of strategy use increased selective recall.

During another session children were given five memory capacity measures: Forward Digit Span, Backward Digit Span, Word Span, Mr. Goodbody, and an Objects Location task. The two memory-for-locations measures (Mr. Goodbody and Objects Location) predicted recall in the selective attention task. Forward Digit Span alone, and Forward Digit Span and Word Span together, predicted selective recall only for children who were consistently selective. None of the capacity measures predicted spontaneous use of the selective strategy. Overall consistency across capacity measures was lacking, but there was moderate, significant correlations between certain pairs of measures. It was concluded that certain individual differences in short-term memory capacity

can be used to predict the facilitative effects of a strategy of selective attention.

CHAPTER 1 INTRODUCTION

Review of the Literature

The ability to gather information in an organized and efficient manner is a fundamental aspect of the development of a skilled information-processing system. When this information gathering involves the selection of relevant visual information from the entire stimulus array, visual selection attention is operating. Furthermore, when these information-gathering procedures are intentional and organized, they are called strategies.

Research on the development of visual selection attention in children has used several measures. Same/different judgments, speeded classification, and incidental learning have revealed both qualitative and quantitative differences in the selective attention of younger and older children (Dane & Swanson, 1982). An overview of these findings is presented below.

Use of the same/different paradigm has shown that older children are better at processing stimuli selectively than are younger children as reflected by both reaction time and accuracy measures (e.g., Day & Potts, 1980; Fick & Franklin, 1973; Smith, Kooles, & Arnoldson, 1975). On tasks of speeded

classification, older children's sorting is less disrupted by the addition of irrelevant features than is younger children's (Stuart, Anderson, & Hall, 1975). Younger children also often fail to use dimensional information for extended classification as efficiently as older children and adults, even though they are capable of distinguishing and attending to dimensional information (e.g., Rosier & Smith, 1978; Shopp & Smith, 1978; Smith & Rosier, 1977).

Rogers and Bain (1968) reviewed a series of studies of incidental learning and concluded that incidental learning remains stable or gradually decreases until about age 11. Throughout early adolescence incidental learning begins to level off and then greatly decreases. That is, after about age 11 attention is allocated to the relevant stimuli. (Also, see a review by Rogers and Frankish, 1972.) Rogers and Goldin (1978) found that even kindergartners could exert considerable control over the allocation of resources during the initial perception and encoding of a visual stimulus. This finding resulted, however, when interesting materials and a meaningful story were included in the task design. Nevertheless, the study by Rogers and Goldin (1978) suggests that even youngest children may be capable of using strategies of selective attention.

More recently, the ability of preschoolers to use strategies of visual selective attention has received increasing consideration (e.g., Miller & Bortis, in press).

Woody-Kamary & Miller, in press). This research on the use of strategies to selectively allocate attention in early childhood and middle childhood has revealed two main areas of developmental change (Miller & Harris, in press; Miller, Tappin, Doherty-Selkirk, & Woody-Kamary, 1998). The first main area of change is in strategy production--the emergence of an appropriate selective strategy and the consistent utilization of that strategy. The second main area of developmental change is in strategy utilization--the ability to derive facilitative effects for subsequent cognitive processing (i.e., recall of relevant objects) once the strategy has been produced successfully. Each of these areas of developmental change in strategy use will now be examined in greater detail.

Strategy Production

A procedure developed by Miller and Willis (1981) has made possible the examination of the steps in the development of the ability to produce a selective attention strategy. This procedure, designed to study visual selective attention, provides the direct observation of the initial utilization of attention. With the use of this task, a developmental sequence has been noted. Specifically, from the limited production of an inefficient task strategy to the final, consistent production of an appropriate selective strategy. Intermediate phases in task-appropriate strategy production have been noted, also.

In the Miller and Weisz (1988) task children decide which animal to view during a study when when they are to try to remember the locations of relevant objects (e.g., animals) but not irrelevant objects (e.g., household objects). Their objects are behind two rows of six doors with pictures of cages (for animals below) or houses (for household objects below). If children open only doors covering relevant objects, it is certain they have not attended at all to irrelevant objects; thus, selectivity need not be inferred from cognitive measures, such as errors in recall. Unlike other assessments, in which performance (recall, non-different judgments, etc.) cannot be assessed separately from the allocation of attention because the latter is inferred from the former, the Miller and Weisz (1988) procedure permits a separate assessment of the two. Thus, it is possible to determine whether selective attention actually improves recall. Another advantage of the Miller and Weisz (1988) procedure is that, unlike with other procedures, it can reveal systematic, but inappropriate (nonselective) strategies, and transitional periods from partial to full use of the selective attentional strategy.

Miller et al. (1988) found different patterns of strategy use on the Miller and Weisz (1988) selective attention task for 4-, 6-, and 10-year-olds. The 4-year-olds often inappropriately used a spatial pattern of door opening (usually row by row, but sometimes column by column) on this

task, the 8- and 10-year-olds, however, tended to use the appropriate selective strategy and rarely used the inappropriate spatial strategy. Partial strategy use was noted at each age level, with consistent use of the selective strategy increasing with age. Similarly, Miller and Weiss (1981) noted a significant increase from grades 1 to 5 in the number of children who used the selective strategy and a significant decrease in the number of children who used the inappropriate spatial strategy. The developmental sequence of strategy production on this task that has surfaced is, thus, as follows: (1) the use of an inappropriate spatial strategy by preschoolers and young young grade-school children, (2) partial use of the selective strategy increasing from 8 to 10 years of age, and (3) consistent use of the selective strategy occurring around 8 to 10 years of age. A study by Battaglia-Bushlow and Miller (in press) that examined use of the selective strategy in extensive grade-school, third and fourth grades-gave further support to this developmental sequence of strategy production.

Strategy Utilization

Once children consistently begin to use the appropriate selective strategy on the Miller and Weiss (1981) task, a lack of development in the critical major aspect of strategy use--effective utilization of the strategy--becomes evident

A transitional period in the facilitative effects derived from appropriate strategy use has been noted in this task (e.g., Benaria-Brockner & Miller, in press; Miller et al., 1986). More specifically, the initial use of the selective strategy often does not result in subsequent facilitation of recall of relevant items. Miller et al. (1986) found that use of the selective strategy did not facilitate the recall of 4-year-olds, whereas 8- and 10-year-olds did benefit from production of the selective strategy. This lag has been referred to as a "utilization deficiency" by Miller (Miller & Harris, in press). A similar lag also has been noted between the use of memory strategies and subsequent recall in young children on other memory tasks (e.g., Baker-Ward, Overtein, & Deidor, 1984; Bjorklund & Berninger, 1987).

Baker-Ward et al. (1984), for example, noted that although 4- and 8-year-olds approached a memory task with similar naming and looking behaviors, only the older children appeared to benefit from these behaviors. That is, only the older children exhibited superior recall when they used these memory mediators. Baker-Ward et al. suggested that only the older children were able to link these memory behaviors up with effective internal memory mediators.

Bjorklund and Berninger (1987) reported that although third and seventh graders employed an organizational strategy (as instructed) in a memory task and showed

comparable expenditures of effort in doing so (as measured by interference as a secondary time-sharing task), strategy use led to recall gains only for the seventh graders. The authors suggested that when memory strategies are imposed on young children, the mental effort expended on strategy use reduces the amount of capacity available for engaging in other cognitive activities. Therefore, young children may not necessarily exhibit the benefits of strategy use for subsequent recall.

The utilization deficiency is different from a "production deficiency" (Flavell, 1980). In the latter, young children may have the competence to produce and benefit from an appropriate strategy, but they often fail to produce it when needed. In contrast, the utilization deficiency is demonstrated by many preschoolers (Sherry-Bassett & Miller, *in press*) and young school-aged children (Cortina-Cooklin & Miller, *in press*; Miller et al., 1988) who produce the relative strategy on the Miller and Meiss (1981) task but do not show better recall necessarily. The utilization deficiency may be considered one particular type of "motivational deficiency" (Flavell, 1981), a more general term that describes the failure of a strategy to facilitate recall.

Utilization Capacity

The utilization deficiency could be due to both the limited processing capacity of preschoolers and young school-aged children and the capacity demands required by various aspects of task performance. Briefly, in terms of a limited capacity model of functional short-term memory (Cove, 1988; Dempster, 1981), stringing production may require less capacity with increasing age (Battersea, 1984) (for a review by Shiffrin, 1978, for evidence supporting a limited capacity model.)

The assumption that the work space of information processing is the same limited-capacity system used by basic of long-term memory (e.g., digit span tests) has received almost universal acceptance in the adult literature (Kopp, Bickman, & Levine, 1983) and in the developmental literature (Ginsburg, 1981). (However, see Bechara & Kopp, 1983, for a contrary viewpoint.) The most influential work on the role of capacity in cognitive development is that of Robbie Case. Case (1985) uses the term "executive processing space" to denote the limited capacity of functional short-term memory. The executive processing space refers to "the maximum number of independent schemes that a subject can keep in a state of full activation simultaneously, while working toward a goal about which some executive decision must be made" (Case, 1985, p.188). The executive processing space is divided into

two main portions: (i) that portion of space that is currently devoted to the activation of new schemes--the operating space, and (2) that portion that is currently devoted to the maintenance and/or retrieval of schemes recently activated--the short-term storage space. Either of these two portions of the executive processing space has a separately defined capacity limit. Together they constitute a single pool of capacity that can be flexibly allocated to either portion. Thus, if the capacity devoted to one increases, the capacity of the other necessarily decreases. Initially, the activation of certain schemes may require a great deal of the overall executive processing space capacity, leaving only a small amount of capacity to be devoted to the storage and/or retrieval of information. As the activation of these schemes becomes increasingly automatic, less operating space is required and more capacity is available in short-term storage space to devote to storage and/or retrieval.

In children just beginning to use the selective strategy on the Miller and Galois (1981) task, the capacity needed to access, consistently execute, and monitor execution of the this strategy may leave little capacity to engage in further substantive activities (e.g., rehearsal or inquiry) or to store relevant items that have been viewed. With practice, as use of the selective strategy becomes more consistent and automatic, it should require less operating space and

consequently free up capacity that could be devoted to further mnemonic strategies (in the operating space) and/or storage (in the short-term storage space). Thus, the Williamson deficiency could reflect a period when the child produces the appropriate strategy, but, because of the high effort demand, does not get benefit from it in his recall performance.

The comments are necessary at this point. One is that there is controversy regarding the role of capacity in cognitive performance. Treisman and Sengco (1980), in their independent-processes hypothesis, argue that the resources that support short-term memory and information processing do not overlap and are independent of each other in cognitive development. In other words, short-term memory and information processing do not compete for a common pool of capacity. The other comment is that although the role of capacity in the focus of the current research and several relevant studies that will be described below, there are other possible explanations of the Williamson deficiency. For example, young children simply may have a production deficiency with regard to further mnemonic activities, even when they have sufficient capacity. That is, young children may not attempt the use of a mnemonic strategy such as rehearsal once relevant stimuli have been viewed, even when they have sufficient capacity to do so, because they simply do not use rehearsal yet.

DeLoache-Davies and Miller (in press) manipulated the effectiveness of using a selective strategy on the Miller and Weir (1981) task by removing it (an experimenter supplied the appropriate strategy by opening only relevant doors for the child). In this condition, result differences between second, third, and fourth graders were no longer significant. This effect was not due to simply supplying a strategy that the younger children did not have, that children had spontaneously produced the selective strategy.

In addition to the effectiveness of supplying the appropriate strategy, there is also effort involved in acquiring this strategy. Woody-Benson and Miller (in press) included a meaningful story (about a child who wanted to remember which toy boxes contained certain types of toys) along with the standard task instructions for preschoolers. They noted a degree of selectivity on this task not usually observed until 7 or 8 years of age. This suggested that the availability of meaningful, relevant script knowledge may facilitate acquiring the appropriate strategy, selectivity. Young children often say have difficulty seeing the relevance of a strategy to one's repertoire for a poorly understood experimental context. Hence, the effectiveness of acquiring the appropriate strategy may contribute to the utilization deficiency in young children.

The Present Study

The present study was designed to more directly study the role of processing capacity in the production and utilization of the strategy of selective attention. The study examines the interrelations among assessing and executing the selective strategy, selective memory performance, and various measures of short-term memory capacity. Using the Miller and Waiss task in a recent study, Miller, Brady-Sampay, and Ainsie (unpublished data) examined young children's selectivity and their subsequent recall of relevant items. Variations of the task were included to reduce (1) the effort required to assess the appropriate (selective) strategy and (2) the effort required both to assess and to execute the appropriate strategy. As the effortfulness of strategy use was decreased, selective recall increased. In the present study direct measures of short-term memory capacity were obtained for each of the children along with measures of selectivity and selective recall using the above task manipulations. Thus, in addition to observing an inferred trade-off of capacity between strategy use and selective recall as the effort of strategy use decreased, an examination of independently measured individual differences in capacity was possible. This permitted the examination of the following issues in strategy use and memory capacity during development:

First, the relations between various short-term sensory capacity measures and performance on the selective sensory task were examined in terms of a limited capacity model. Guttenberg (1988) inferred the relative demands that a cumulative rehearsal strategy made on capacity by noting performance on a simultaneously performed finger-tapping task. Young school-aged children experienced a greater decline in finger-tapping when told to rehearse than did older school-aged children. Guttenberg (1988) suggested that strategy use may require less capacity with increasing age. Applied to performance on the Miller and Weir task, this would predict a greater tendency of children with high capacity to engage in further mnemonic activities once relevant objects have been viewed.

Frawley, Scerif-Gull, Deane, and Schneider (1987) recently examined the role of short-term sensory capacity in the ability to use an imagery strategy to aid recall. Specifically, short-term sensory capacity was used as a predictor of the degree to which instructions to use imagery facilitated recall in children 6 to 11 years of age. Measures of short-term sensory capacity made unique contributions (independent of age and verbal competence) to the prediction of sentence recall in the group instructed to use imagery but not in a control group. Frawley, Scerif-Gull, Deane, and Schneider (1987) concluded, more generally, that short-term sensory capacity predicts performance only

which short-term memory is taxed. More specifically, short-term memory predicted performance only when children were instructed to use an effortful memory strategy. High-capacity children were more likely to benefit from such instructions, presumably because they had more remaining capacity to devote to further cognitive processing.

The present study extended the Pressley, Carlisle-Hall, Beane, and Schneider (1987) findings in three main ways. First, a more direct measure of strategy use was included--the frequency and pattern of free responses to free-recall prompts as compared to a covert, instructed strategy of memory construction. This permitted the determination of whether subjects instructed to use a mnemonic strategy followed the instructions to an equal extent and whether, on noninstructed trials, spontaneous strategy use was affected by amount of short-term memory capacity. Pressley, Carlisle-Hall, Beane, and Schneider (1987) assumed that subjects did not spontaneously use memory and did so when instructed, but the presence or absence of this undetectable strategy could not be assessed. Second, the relationship between short-term memory capacity and strategy use was assessed on a memory-for-locations task that is not as heavily dependent on verbal abilities as is sentence recall. Finally, the present study more fully examined the relationship between capacity and strategy use by including two levels of effortfulness of strategy use. In addition to a condition

instructing children to use an appropriate strategy (and, thereby, reducing the effort to manage the strategy), is another condition an experimenter removed the strategy from the child (thus, additionally removing the effort required to manage the strategy). According to Freytag, Osofsky-Bell, Jansa, and Schneider (1987), capacity should predict recall better in the more effortful former condition than the latter, especially among children who did not spontaneously use the selective strategy. In addition, increased effortfulness of strategy use should result in less capacity that could be devoted to short-term storage of relevant information. Thus, selective recall of relevant items was expected to suffer as the effort required to use the selective strategy was increased.

In the present study short-term memory capacity measures were examined specifically as predictors of various aspects of the task: (1) the tendency to produce a strategy and recall on the selective attention task, (2) the ability to recall when capacity demands are high, and (3) the ability to recall when capacity demands are lower (low levels of lower capacity demands). Thus, this study was a more refined look at the relationship between capacity and phases of a memory task.

A secondary focus of the present study was on the degree of consistency between various commonly used memory capacity measures. First, do some measures support the above

hypothesis better than other measures? Daneman and Carpenter (1980), for example, found that performance on both a reading span measure and a listening span measure correlated with measures of reading comprehension in adults, whereas traditional digit span and word span measures did not.

Second, the subjects tend to have about the same relative standing on all of the measures? Daneman (1985) suggests that different measures of short-term storage span should be uniformly positively correlated. A child who has a very large executive processing span should have an advantage over others with a smaller executive processing span, regardless of the specific operations required by the task. In other words, all measures of short-term memory capacity should be significantly intercorrelated, since they all tap the same underlying executive processing span. However, the intercorrelations should not be high because each short-term memory capacity measure is specific to a particular class of mental operations.

The following measures of short-term memory capacity were included in the present study: (1) *Wc* (Wechsler Adult Reading Test, Case, 1946); (2) *Word Span*, (3) *Forward Digit Span* (McCarty, 1972), (4) *Backward Digit Span* (McCarty, 1972), and (5) a memory task of object locations within an array. The *Wc*, *Forward Span* and *Object Location* tasks were included as an assessment of memory-for-locations capacity, as recall in the listening attention task requires memory for object

locations. These two assessments, therefore, should tap visual-spatial abilities similar to those necessary for selective recall. This especially should be true for those children who do not rely primarily on verbal rehearsal to aid selective recall. However, the Objects Location task requires memory-for-locations of line drawings similar to those included in the selective recall task. Thus, these two assessments should be sensitive predictors of selective recall to the extent that individual differences in memory capacity are specific to a class of mental operations. Note that Bassman and Carpenter (1980) found that individual differences in capacity predicted degree of reading comprehension in adults only when measures were used that required visual abilities (e.g., reading span and listening span). The Mr. Cucumber task has been used by Lane (1988) in several studies, and the Objects Location task was developed for the present study.

The Forward Digit Span was included as a traditional span measure often used in standardized assessments of short-term memory capacity in children (e.g., McCarthy, 1973; Stanford-Binet Intelligence Scale: Fourth Edition, 1976; Wechsler Intelligence Scales for Children-Revised, 1974). Word Span was included as an alternate span measure that measures memory for verbal information, rather than material information. Finally, Backward Digit Span, also a traditional measure of short-term memory capacity (e.g.,

Roberts, 1971, *Stanford-Binet Intelligence Scale Fourth Edition*, 1968, *Wechsler Intelligence Scale for Children-Revised*, 1974), was included as a memory capacity measure that makes a heavier processing demand by requiring the transformation (reordering of verbal input). Whereas the other capacity measures should require primarily capacity for short-term storage of information and only slight operating space capacity, the Stanford-Binet Span should require a greater degree of operating space.

History of Hypotheses

Specifically, the following hypotheses regarding strategy use and short-term memory capacity were assumed. First, short-term memory measures were expected to predict selective recall in the condition that reduced only the effortfulness of executing the selective strategy. The recent study conducted by Miller et al. (unpublished data) suggests that the capacity demand in this condition was not within the range of all children. Capacity measures were expected to predict recall less well or not at all in the condition which reduced both the effort to execute and to execute the selective strategy. This follows from the Freedley-Charlton-Buhl, Snow, and Schneider (1987) finding that memory capacity affords prediction only when strategy use is effortful.

Second, it was not clear whether the memory capacity measures would predict selective recall better in the condition that reduced the effort to maintain the short-term strategy (when the child was instructed to use the selective strategy) than in the condition that provided a baseline measure of spontaneous strategy use, as Freedberg would predict. If selectivity in the baseline condition was low, then Freedberg would be correct because it should be essential for the children to exercise the strategy when instructed to do so. If selectivity in the baseline condition was high (as suggested by the Miller et al. [unpublished data]), then the short-term memory capacity measures would predict selective recall better for the baseline condition than for the condition that reduced strategy executing effort. However, prediction would still be least accurate for the condition that reduced both the effort to access and to execute the strategy.

Third, children with high capacity were expected to be more selective in the baseline condition than were children with low capacity. The most advanced strategy (i.e., the consistently selective strategy) is assumed to be the most efficient and, thus, the most demanding of capacity for young children. Therefore, only those children with sufficiently high capacity were expected to reveal consistent use of the selective strategy. Additionally, short-term memory capacity and strategy use in general were

examined to find whether progression through the developmental sequence of strategy use (use of an inappropriate spatial strategy, partial use of a selective strategy, consistent use of a selective strategy) noted by Miller et al., (1980) was positively correlated with capacity. That is, children with higher capacity would be expected to use a more advanced strategy in the hypothesized sequence of strategy use. With each forward advance in the sequence, strategy use requires the retention of more information in short-term memory. For example, at the lowest level of strategy use, the child attends primarily to the spatial layout of the stimuli and space draws according to a consistent spatial pattern. However, as the child attempts to use a selective strategy, both the spatial layout of the stimuli and the drawings denoting either one of two categories of objects underneath (i.e., animals or household objects) must be attended to.

Fourth, the two spatial location capacity measures, Re-Remember and the Object Locations task, were expected to correlate most strongly with Recall, in general, as each requires memory for spatial locations available to the selective recall demands (rather than auditory memory for words or digits). Forward Digit Span and Word Span may be better predictors of subsequent memory activities (such as rehearsal), since rehearsal items have been viewed. Therefore, these two measures should be better predictors of

performance in the second stage of Bayen and Hale's two-stage model of selective attention--the stage during which further rehearsal processing of relevant information occurs. With the Forward Digit Span, this may be true even for those children who fail to engage in further mnemonic activities after viewing the relevant items. This is because Forward Object Span requires sequential access for the information presented and may tap visual-spatial abilities in those children who do not rehearse. Backward Digit Span may predict use of the selective strategy better than the other measures due to its heavier processing demand on memory capacity.

Finally, Case's (1984) theory would predict that the five different short-term memory capacity measures should be moderately positively correlated. Therefore, consistency among the capacity measures was expected.

CHAPTER 11 METHOD

Subjects

The subjects were 61 kindergarteners ($M = 5$ years, 11 months, range = 5 years, 0 months to 6 years, 8 months) and 42 first graders ($M = 7$ years, 8 months, range = 6 years, 0 months to 8 years, 8 months) with approximately equal numbers of males and females in each grade. All children returning signed forms indicating parental approval were tested. The children came from a predominantly white, middle-class suburban area.

Materials and Procedures

Children's Russian Russian

The apparatus and materials were those used by Miller and Nelson (1981). Their procedure was adopted for use with younger children. The stimuli that could be examined were inside an aluminum box (40 x 35 x 10 cm) placed on a table in front of the child. The top of the box consisted of a 5 x 8 matrix of doors. Each door could be opened up and away from the child by lifting an attached knob. Half of the doors had a drawing of a cup on them and carried a drawing of a familiar animal. The other six doors had a drawing of a

house and hid drawings of familiar household objects. On the Selection Recall task the child was to remember the locations of relevant objects (i.e., animals for half the children, household objects for the other half). Each vertical pair of drawings under a column of two doors contained one animal and one household object (e.g., dog and table). Each animal was vertically paired with a different household object on each trial. Different objects appeared on every trial and each row contained some animals and some household objects.

Before the search trial, the child was shown a large card with all the animal pictures and all the household pictures to familiarize her with the stimuli. The experimenter explained that all the animals were under doors with cages on them and all the household objects were under doors with houses on them; half of the children were told to remember which door each animal was under, and half were told to remember which door each household object was under. The children were told to look under whatever doors they wanted, as many times as they wanted during the study period, and to open only one door at a time. They were told to use their writing hand.

There were three sets of two trials each. The first set was the *Spontaneous condition*, because any strategy was was spontaneous on the part of the child. This was a *baseline*. The second and third sets, with the order counterbalanced, were the *Child Open (OO)* condition (child was told to open

only relevant doors) and the Adult Open (AO) condition (default opened only relevant doors). In the CO condition the effort required to access the appropriate selective strategy has been removed. In the AO condition the effort required both to access and to execute the selective strategy has been removed.

The task incorporated the following story and instructions to insure understanding of the task goal:

The memory game we are going to play has a story to go with it, and when you play you will pretend to be the girl (Jenny) in the story. You will try to do what she (he) has been told to do. Jenny (John) is a child who likes to go to school and has a lot of fun there. One day Jenny's (John's) teacher tells her that the next morning is special because the children will get to play a special learning game with some fun toy toys--some toy animals (toys to play house with). The toys are in their boxes. Some of the children have to remember where the toy animals are, and some have to remember where the toys to play house are. Jenny's (John's) teacher tells her (him) to remember where each animal (house) toy is so she can find them really fast in the morning.

Following this story and instructions to remember the locations of relevant objects (e.g., animals or household objects), children were asked to point to the doors hiding the relevant objects. A practice trial then followed. Before each test trial the children were again told what they were to remember. Each test trial consisted of a 20-second study period during which the doors could be opened to view objects and a subsequent test of recall for the locations of relevant objects. During the test of recall, the child was required to indicate the locations of relevant objects by

placing drawings of these objects on top of the appropriate doors. No feedback was given.

In the *Child Opens* condition the experimenter also told the child to look inside only the boxes with the animal (household) toys in the exact same way as was demonstrated. The experimenter then demonstrated this selective strategy for the child by opening only the relevant doors in order from the child's left to right sides and then repeated the sequence. The child was then asked to show the experimenter how he was going to open the doors. This insured that the child fully understood how to carry out the instructed selective strategy. In this condition the child was given as much time as he needed to open each relevant door in order across the apparatus and then repeat the sequence as instructed.

In the *Adult Opens* condition the experimenter told the child that it was her (the experimenter's) turn to open the doors. The experimenter then told the child that she was going to open only the boxes with the animals (household) toys once all the way across the apparatus and then repeat the sequence. She proceeded to demonstrate this selective strategy to the child (as in the *Child Opens* condition) and did so within a 30-second study period (same time period as in the *Spontaneous* condition).

Memory-Spancity Session

Five measurements of memory spancity were used. (1) Er Guscher (abbreviated version from Chen, 1981), (2) Wood Span, (3) Forward Digit Span (adapted from Wechsler, 1972), (4) Backward Digit Span (adapted from Wechsler, 1972), and (5) an objects location task. Er Guscher is a task in which children are presented with a clown figure with one or more of its body parts painted a bright color (see Appendix A). The picture is removed after 5 seconds or when the child looks up (whichever occurs first). A card is then presented for 5 seconds and then is replaced with the clown figure with no parts colored. The task is to point to the body parts that were colored in the previous picture. Trials differed as to the number (gradually increased from 1 to 6) and location (i.e., nose, legs, eyes) of colored stickers that were placed on Er Guscher. In the present study, following two practice trials, there were ten trials each of one-spot, two-spot, three-spot, four-spot, five-spot, and six-spot items. Therefore, the total number of spots that could be recalled across the 12 trials was 62.

The Wood Span task required children to repeat increasingly longer sets of one-syllable common concrete nouns (e.g., top, bird, truck) after each segment had been presented orally by the experimenter. All words were presented at the rate of one word per second. The children were told to remember the words in any order. Following an

initial practice trial, two trials were presented of each three-word, four-word, five-word, six-word, and seven-word sequence. Thus, a total of 50 words could be recalled on this task.

The McArthur (1972) Forward Digit Span task was adapted only by always presenting the children with two trials at each digit sequence level rather than presenting a second trial at each level only if the first had not been completed successfully. (The Memory for Digits subtest of the Wechsler Intelligence Scale for Children-Revised, 1974, is administered likewise.) Therefore, a child must successfully recall digit sequences at each level twice (as opposed to only once) in order to receive full credit for digit recall at that level. This was thought to be a more reliable measure of digit span. The task began with a practice trial then in subsequent test trials, the digit sequences gradually increased in length from two-digit sequences to seven-digit sequences. Thus, there were 12 trials.

The Backward Digit Span (McArthur, 1972) was adapted in the same manner as was the Forward Digit Span. The Backward Digit Span sequences gradually increased in length from two-digit sequences to six-digit sequences. Therefore, there was a practice trial followed by 10 test trials on this task.

The Objects Location task required children to view a horizontal array of 6 line drawings presented simultaneously for 6 seconds and then recall the spatial location of each

object in the array. The arrays were composed of objects not included in the selective attention task (e.g., boat, hat, cheese), and no two objects in any array had obvious categorial relations (e.g., food, toys, clothing). During the test of recall the child was required to indicate the locations of the objects by placing drawings of the objects on a horizontal array of empty position blocks. Each child received 1 practice trial and 4 test trials on the Objects Location task.

In order to obtain optimal performance for each child on each of the measures, each task consisted of the following number of correct test trials (with two trials at each capacity level where applicable), as previously described: Wt. Discrim--12, Word Span--12, Forward Digit Span--12, Backward Digit Span--12, Objects Location--4. However, both the Forward Digit Span and Backward Digit Span tasks were terminated after the child failed two consecutive trials. The children were given a brief break during the session.

Design

The presentation order of the selective attention measures and the memory capacity measures was counterbalanced within each age group. Additionally, the order of the five memory capacity tasks was counterbalanced. Four orders were used. The Forward Digit Span and Backward Digit Span tasks were always presented sequentially with the Forward Digit Span

task presented first. The digit span tasks occurred once in each possible position across the four orders. The remaining positions in each order were filled randomly with the other tasks. The four orders were (1) Forward and Backward Digit Span, Word Span, Mr. Gumbler, Objects Location, (2) Word Span, Forward and Backward Digit Span, Objects Location, Mr. Gumbler, (3) Mr. Gumbler, Objects Location, Forward and Backward Digit Span, Word Span, and (4) Objects Location, Mr. Gumbler, Word Span, Forward and Backward Digit Span.

Each session lasted approximately 15 minutes. Approximately one week lapsed between sessions for each child. During each session each child was tested individually in a private room at the school.

Gelling and Rooding

Selective Attention

A selectivity score was derived for each child on the spontaneous strategy test trials by computing the proportion of total doors opened that were relevant. That is, the number of doors opened that were relevant was divided by the total number of doors opened to yield a selectivity score for each child. Additionally, each of these two trials was classified for each child according to the pattern of responding. Fitts's categories (adapted from Miller et al., 1988) were: (1) consistently selective (at least 75% of the

doors opened covered relevant objects), (2) consistently spatial (at least 75% of the door openings were row by row), (3) partially strategic (either 50-74% of the doors opened covered relevant objects, or 50-74% of the doors were opened in a spatial pattern), and (4) other (less than 50% of the door openings were either selective or spatial). Two raters independently classified 48 trials and achieved 74% agreement. Finally, the total number of object locations correctly recalled (0nd possible) was recorded for each of the six trials.

Memory Scoring

On both the Forward Digit Span task and the Backward Digit Span task the child was given one point for each trial successfully repeated in the appropriate order. The maximum possible score for the Forward Digit Span task was, thus, 12 points. A possible 50 points could be earned on the Backward Digit Span task.

On the Word Span task one point was given for each word correctly recalled from each sequence, regardless of the order of recall. Therefore, a maximum score of 16 was possible. On the Objects Location task one point was given for each object location correctly recalled, resulting in a maximum possible score of 16. Finally, the total number of colored body parts correctly recalled on the 12 Cucumber task determined this score. A maximum score of 48 was possible.

CHAPTER 11 RESULTS

The results are presented in the following order. Preliminary analyses examined whether variables that were not a focus of the study significantly affected performance on the memory capacity measures. Consistency in performance across the five memory capacity measures was then examined. This facilitated the final analyses which examined the predictive value of the memory capacity measures for spontaneous strategy use and subjective recall.

Memory Capacity

Preliminary analyses were conducted for each of the five individual memory capacity measures to determine possible effects of variables not of interest in the study. Each of the capacity measures was entered singly as a dependent variable into an Analysis of Variance (ANOVA). Independent variables were grade (2), order of presentation (the capacity tasks (4), and stimulus order (2). Memory capacity measures within FIDIC or second). Only one significant blocking main-effect was found of grade on backward Digit Span, $F(1,40) = 11.45$, $p < .001$. The main backward Digit Span was 1.75 for kindergarten and 3.70 for first graders. The

variables of order of presenting the capacity tasks, session order, and sex were analyzed in subsequent analyses of memory capacity, as they were shown to have no significant effect on performance. The mean scores, the ranges, and the standard deviation for each of the five memory capacity measures are presented below in Table 1.

TABLE 1

Mean Scores, Ranges, and Standard Deviations For each Memory Capacity Measure (SDNs)

Test	Mean	Range	Standard Deviation
Forward Digit Span	8.95	3.00--10.00	1.47
Backward Digit Span	3.35	1.00--6.00	1.08
Word Span	10.40	17.00--41.00	4.83
Objects Location	14.03	1.00--22.00	4.51
Mr. Cornsby	23.38	13.00--33.00	5.80

Consistency in performance across the memory capacity measures was examined through correlational analyses. Pearson r correlations among the five capacity measures across both grades are shown in Table 2 below.

It should be noted that the strongest relations occurred between the span measures, Forward Digit Span and Word Span, $r = .58$, $p = .001$. The two spatial location capacity measures, Objects Location and Mr. Cornsby, were most weakly correlated, $r = .12$, $p = .00$. Backward Digit Span was

TABLE 3
Pearson Correlation Coefficients for Memory Capacity
Measures (SPSS)

Test	Forward Digit	Backward Digit	Word Span	Objects Location	Wt. Remember
Forward Digit Span	1	0.18	***0.58	0.13	***0.29
Backward Digit Span		1	***0.17	***0.23	-0.13
Word Span			1	0.07	***0.27
Objects Location				1	***0.32
Wt. Remember					1

SPSS®
* p < .05.
** p < .01.
*** p < .001.

weakly, but significantly, correlated with both Word Span, $r = .57$, $p < .01$, and Objects Location, $r = .23$, $p < .05$.

More correlational analyses were conducted within each grade wherein different correlational patterns were revealed for the two age groups. These results are shown in Table 3.

Whereas the Forward Digit Span and Word Span measures were significantly correlated in both grade levels, the two spatial capacity measures (Objects Location and Wt. Remember) were significantly correlated only for the first graders. Backward Digit Span was correlated with Word Span,

Table 3

Pearson Correlation Coefficients for Capacity Measures within each Grade (Listed for grades K and 1, respectively)

Test	Forward Sight	Backward Sight	Word Span	Object Location	Mr. Goodbar
Forward Sight	1	0.16	***0.47	0.15	***0.33
Span	1	-0.10	***0.37	-0.08	***0.09
Backward Sight		1	***0.38	0.14	-0.13
Span		1	0.06	***0.31	0.06
Word Span			1	0.04	0.14
			1	0.08	0.17
Object Location				1	0.13
				1	***0.33
Mr. Goodbar					1

Notes

There were 41 kindergarten and 41 first graders.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

*** $p < .0001$.

$g = .18$, $g = .41$, for kindergarten and with Object Location for first graders, $g = -.11$, $g = -.08$. In summary, spatial consistency across the short-term memory capacity measures was lacking, but there was a moderate correlation within certain pairs of capacity measures. In addition, the pattern of the correlations differed somewhat for each grade.

Based on the above analyses, in subsequent analyses of the predictive value of the memory capacity measures, the predictive value of each individual measure was examined

initially. Next, memory capacity composites were formulated based on the above patterns of correlations, and their value in predicting spontaneous strategy use and selective recall was examined. The composites were constructed in an effort to obtain a more refined estimate of each child's short-term memory capacity. First, three different capacity predictors were formed as follows: The standardized scores on the Forward Digit Span and Word Span tests were summed to form a span composite (8) due to the strong relation between the two capacity measures both across and within grade. The standardized score on the Backward Digit Span was used as the second composite (90), as this measure showed a different pattern of relations with other capacity measures in each grade across grade. Backward Digit Span was not strongly correlated to any other memory capacity measure (maximum r was .27). Finally, the standardized scores on the Objects Location task and the Pi- Calculator task were summed to form a third grouping composite (90). These two measures were moderately correlated across grade and showed an even stronger relationship for the first graders.

Next, an overall capacity composite was formed for each child by summing the standardized scores on the five memory capacity measures (Total Capacity). This overall composite was used as a general index of each child's short-term memory capacity.

Memory Capacity and Spontaneous Strategy Use

Memory Capacity and Spontaneous Prediction of the Selective Strategy

One question of interest was whether children with higher short-term memory capacity would exhibit a greater degree of selectivity on the Spontaneous trials. A preliminary ANOVA was conducted to examine the effects of grade (2), session order (2), sex (2), and relevant stimuli (2) [animals or household objects] on the tendency to use a selective strategy in the Spontaneous condition (baseline condition). The main proportion of doors opened that were relevant on the Spontaneous trials (Selectivity, $S = .72$) served as the dependent variable. The model was nonsignificant both with and without interaction effects; therefore, the variables of grade, session order, sex, and relevant stimuli were eliminated from subsequent analyses of spontaneous strategy use.

The primary analyses of memory capacity and spontaneous strategy use thus were conducted. Each of the individual memory capacity measures was entered into a separate general linear model as an independent, continuous variable along with the classification variables of grade (2) and the grade by memory capacity interaction. The dependent variable was Selectivity, the main proportion of doors opened that were relevant on the Spontaneous trials. In each analysis the interaction term was nonsignificant. Consequently, the interaction term was deleted from each model. In no model was the grade or memory capacity variable significant.

Next, each of the three memory capacity components was examined individually as a predictor of selectivity on the Spontaneous Trials. Each composite, A, B1, and C2, was entered into a separate general linear model as an independent continuous variable along with grade (1) as an independent classification variable and the grade by memory composite interaction. Selectivity was the dependent variable. Once again, the grade by memory composite interaction was nonsignificant in each model. In the models with the interaction term deleted, neither the main effect of grade nor that of memory composite was significant.

Finally, the overall memory capacity composite, Total Capacity, was examined as a predictor of spontaneous selectivity. The variable of grade was not included in this analysis, as it had failed to have any significant effects in any of the previous analyses. Therefore, a regression analysis was conducted using the capacity measure, Total Capacity, as the independent variable and the degree of spontaneous selectivity, Selectivity, as the dependent variable. No predictive value was gained by using the overall memory capacity composite, as Total Capacity also failed to significantly predict spontaneous selectivity. Therefore, children with greater short-term memory capacity were not significantly more selective on the Spontaneous trials.

Memory Capacity and Overall Type of Strategy Used

Another question concerned the predictive value of short-term memory capacity for the overall type of strategy used on the Spontaneous trials, although memory capacity failed to predict the degree of selectivity on the Spontaneous trials, might it predict a child's general strategic approach (selective or otherwise) to gathering information on this task? As memory capacity increased, would the appropriateness of the type of strategy used also increase? In other words, would children with a higher degree of memory capacity tend to use a more advanced strategy in the developmental sequence of strategy use previously noted by Miller et al. (1969)? In order to examine this issue, the pattern of door openings on each of the two Spontaneous trials was classified according to the coding scheme described earlier (e.g., consistently selective, consistently optimal, partially strategic, and other). Each child was classified according to the most advanced strategy type used across the two trials. Because there were large differences among the frequencies of strategy types used, these data are presented descriptively. Table 4 presents the mean score on each of the individual memory capacity measures for the most advanced type of strategy used by the children.

A general pattern arose in groups across the different memory capacity measures and type of strategy used. With the

TABLE 4

Mean Capacity Scores for Most Advanced Type of Strategy Used

Strategy Type	Forward Scale	Backward Scale	Word Test	Object Location	% Correct
Consistently Selective (38)	8.62	7.24	32.56	12.86	23.68
Consistently Spatial (20)	9.70	7.70	32.80	12.80	23.40
Partially Strategic (18)	8.64	7.21	32.50	15.29	28.98
Other (1)	2.00	1.00	18.00	17.00	21.00

N=60.

The number of children who used each type of strategy is given in parentheses.

exceptions of mean for the Object Location measure, the following pattern appears to emerge. Surprisingly, children with the highest memory capacity tended to use a consistently spatial strategy rather than the most appropriate consistently selective strategy. The one child who used the least efficient strategy (the "Other" strategy type) had the lowest capacity score by far on all but one of the measures. However, a "mean" of one score obviously should be interpreted most cautiously.

For the purpose of further analysis, the "partially strategic" and "other" classifications were combined into a single "other" category of strategy types. ANOVAs were then conducted to examine whether strategy type (consistently selective, consistently spatial, or other type of strategy

was predicted level of short-term memory capacity for any of the individual capacity measures or the capacity composites. None of the models were significant, however.

Memory Capacity and Selective Recall

Other Effects on Recall

Before examining the effects of capacity on the various recall conditions, it is necessary to examine the effects of other variables, especially condition and selectivity, on recall. A preliminary analysis was conducted to examine the effects of spontaneous selectivity on the Spontaneous trials (Selectivity), grade (G), order of selective attention conditions (E: Child Space before or after Adult Space), session order (S), and sex (X) on selective recall. The mean number of relevant object locations correctly recalled (out of 4 possible per trial) in each of the selective attention conditions (Spontaneous, Child Space, and Adult Space) was calculated. Then the selective recall score was entered as the dependent variable into a general linear model, with repeated measures on the independent variable of condition (2). No significant interactive effects involving grade, order of selective attention conditions, session order, or sex were revealed. Hence, the analysis was repeated excluding the interaction effects. These variables still failed to have a significant effect and were, therefore, eliminated from further analysis of selective recall.

One additional preliminary analysis was conducted to examine the effects of relevant stimuli (3 animals or household objects) on selective recall. A general linear model was used in which selectivity was a continuous independent variable and relevant stimuli (2) was a categorical independent variable. Selective recall served as the dependent variable with repeated measures on condition (2). No significant effect of relevant stimuli was revealed, and this variable was also eliminated in further analyses of selective recall.

Following these preliminary analyses, then, selective recall was analyzed within a general linear model with spontaneous selectivity (selectivity) entered as a continuous independent variable. Grade (2) and condition (2) were entered as categorical independent variables with repeated measures on condition. A significant Condition X Selectivity interaction effect, $F(2,180) = 3.22, p < .001$, was indicated. A follow-up analysis of the Condition X Selectivity effect was conducted through the use of regression analysis. A separate regression analysis was conducted for selective recall in each of the three conditions (Spontaneous, Child Open, and Adult Open). The selectivity score, Selectivity, was entered as the independent variable. Selectivity had a significant effect on selective recall in the Spontaneous condition, $F(1,60) = 22.23, p < .001$, but not in the Child Open or Adult Open

conditions. Thus, reducing or eliminating the effortfulness of strategy use in the Child Space and Adult Space conditions eliminated the advantage. For recall, of being significantly selective.

The mean selective recall in each of the three conditions was: Spontaneous = 1.87, Child Space = 1.77, and Adult Space = 4.23. Within-subject t tests (with uncorrected critical values for multiple comparisons) indicated that selective recall was significantly lower in the Spontaneous than in the Child Space condition ($t = 4.11$, $p < .01$), the Spontaneous than the Adult Space condition ($t = 8.84$, $p < .01$), and the Child Space than the Adult Space condition ($t = 2.51$, $p < .01$). Thus, as expected, each experimental manipulation included to reduce the effortfulness of strategy use did significantly increase selective recall. The condition intended to be the least effortful produced the greatest recall.

Individual Capacity Measures and Selective Recall

The rest of the Results chapter contains the main questions of interest. Each of the five individual memory capacity measures was examined separately as a predictor of selective recall. Due to the lack of a significant main effect or interactive effect of grade in the above main analysis of selective recall and in the previous analysis of spontaneous selectivity, grade was not included in any

further analyses of selective recall. A regression model was used with selective recall as the dependent variable with repeated measures as condition (K). In each analysis, two possible outcomes would be of interest. One would be a significant interaction between condition and memory capacity, and the other would be a main effect of memory capacity. Any main effects of condition will not be reported, because they simply repeat the condition effect reported earlier.

In the models that examined the predictive value of Forward Digit Span, Backward Digit Span, and Word Span there were no significant main or interactive effects of memory capacity. When the Objects Location measure was used as a predictor of selective recall, a significant effect of Objects Location, $F(1,81) = 5.89$, $p < .05$, was revealed. Finally, the Wt. Number capacity measure significantly predicted selective recall, $F(1,81) = 9.46$, $p < .01$, in the final model. This pattern of results does not simply confirm the fact that some capacity measures have higher variances than others. For example, Word Span, which had the highest variance, was not a significant predictor. Refer back to Table 1 for the mean score and standard deviation on each of the individual capacity measures.

As hypothesized, the two spatial location memory capacity measures were the best predictors of selective recall. Contrary to predictions, however, a significant interaction

between any measure of memory capacity and condition in predicting selective recall was not revealed. Hence, conclusive evidence of a relationship between effortfulness of strategy use and capacity as a predictor of recall is lacking. It had been hypothesized that if spontaneous selectivity was high, then capacity measures should predict selective recall better in the spontaneous condition. Although selectivity, overall, was fairly high ($\bar{g} = .73$ chance = .44), some children were not very selective. Thus, to more clearly test the hypothesis, each of the above regression analyses was repeated, with spontaneous selectivity added into each model as a covariate. This provided the determination of whether memory capacity provided any unique predictive value once differences in spontaneous selectivity had been accounted for. Therefore, five different regression analyses were conducted to examine the effect of each individual capacity measure, spontaneous selectivity (selectivity), and condition (2) on selective recall, with repeated measures on condition. Of particular interest would be interactions of the capacity measure and selectivity, and, to a lesser extent, condition and selectivity. The former would show that there are differential effects of capacity on selective recall according to the degree of spontaneous selectivity. The latter would show that the ability to spontaneously produce and maintain the selective strategy aids selective recall.

only when a certain amount of effort is required for selective recall.

When Forward Digit Span was entered into the model with a capacity by selectivity interaction variable and Selectivity as a covariate, a significant Forward Digit Span X Selectivity interaction [$F(1,88) = 5.10, p < .05$, was revealed. When Backward Digit Span, Word Span, Object Location, and Age (months) were each entered into separate regression models along with Selectivity and the capacity by selectivity interaction variable to predict selective recall, no significant Selectivity by memory capacity effects emerged.

Follow-up regression analyses were conducted separately for nonselectively selective (at least 75% of the items repeated on both Spontaneous trials covered relevant objects) and less selective children to examine the interactive effect of Forward Digit Span and selectivity on selective recall. Forward Digit Span predicted recall for those children who were at least 75% selective on both Spontaneous trials, $F(1,40) = 5.74, p < .05$, but not for those children who were less selective. However, the fact that there was no significant Forward Digit Span X Condition interaction for the selective children is contrary to the hypothesis that the effect of capacity should be greatest on the Spontaneous trials.

backward Object Open and Word Open each were entered into the model again with the capacity by selectivity interaction term deleted. The capacity variable failed to significantly predict selective recall in either model. However, when Objects Location and Selectivity were used to predict selective recall and the capacity by selectivity interaction variable was deleted from the model, a significant Condition X Selectivity interaction was indicated, $F(2,142) = 9.38$, $p < .001$, along with a significant main effect for Objects Location, $F(1,81) = 6.88$, $p < .01$, and Selectivity, $F(1,81) = 5.38$.

Finally, the regression model that included Rr, Duration and Selectivity in prediction of selective recall with the capacity by selectivity variable deleted revealed a significant Condition X Selectivity interaction, $F(2,142) = 9.88$, $p < .001$, and a significant Condition X Rr-Duration interaction, $F(2,142) = 3.86$, $p = .04$. Significant main effects of Rr-Duration, $F(1,81) = 18.91$, $p = .001$, and Selectivity, $F(1,81) = 6.87$, $p < .01$, also emerged.

Follow-up regression analyses conducted within each condition indicated that capacity (Rr-Duration) significantly predicted recall only in the Spontaneous condition, $F(1,82) = 18.88$, $p < .001$, and explained 13% of the selective recall variance in the Spontaneous condition. When both Rr-Duration and Selectivity were included in the model, 15% of the variance in selective recall was accounted for by these variables.

In summary, these results suggest that once individual differences in spontaneous strategy use have been accounted for, individual differences in the 8r Decoder capacity measure do predict selective recall differentially according to the effortfulness of strategy use, as hypothesized. Differences in Forward Shift Span predict selective recall only for those children who spontaneously use the extensive strategy in a consistent manner. However, this capacity measure does not predict selective recall differentially for those children according to the effortfulness of strategy use. Thus, there is some support for the hypothesis that memory capacity predicts selective recall performance only when strategy use is more effortful.

Memory Capacity Composites and Selective Recall

The memory capacity composites were run through the same sets of analyses as were the individual capacity measures in order to obtain more sensitive predictive models of selective recall. Initially, each of the three memory capacity composites (3, 55, and 60), was entered into separate regression models along with condition (0=with repeated measures) as a predictor of selective recall. 60 (composed of Object Location and 8r Decoder scores) was the only capacity composite that surfaced as a significant predictor of selective recall, $F(1,87) = 11.16, p < .001$. Thus, the analyses with the composites are congruent with those with the individual measures.

The unique predictive value of each of the three memory components B, BB, and BB, was then examined after the effect of spontaneous selectivity (Selectivity) had been introduced into the regression model. Thus, each component was entered as an independent variable into a separate regression model along with the independent variables of Selectivity and condition (B), with repeated measures on condition. Selective recall (the mean number of relevant objects recalled in each condition) was the dependent variable.

In the model examining the effect of B (composed of Forward Digit Span and Word Span scores) and the capacity by selectivity interaction variable on selective recall, significant interactions between B and Selectivity, $F(1,89) = 3.84$, $p = .05$, and between condition and Selectivity, $F(1,89) = 3.83$, $p < .001$, were noted. When BB and BB each were entered into separate regression models with Selectivity, condition (B—with repeated measures), and the capacity by selectivity variable, neither BB nor BB significantly predicted selective recall.

Follow-up regression analyses for the B B Selectivity interaction were conducted by examining the effects of the B capacity component on selective recall separately for consistently selective (at least 75% of the items spanned on both spontaneous trials covered relevant objects) and less selective children. Condition (B) was also included in the

model with repeated measures specified, individual differences in β significantly predicted selective recall for consistently selective children, $F(1,88) = 4.12$, $p = .05$, but not for the less selective children. This outcome is consistent with the earlier analysis with Forward Digit Span alone.

In a subsequent analysis, when β was again entered into the model and the capacity by selectivity main effect was deleted, β still failed to predict selective recall. However, when α was substituted in the model as a predictor and the nonsignificant interaction term for α and Selectivity was excluded, α was found to have a significant effect on selective recall, $F(1,42) = 13.74$, $p = .001$. A significant Condition $\times$ Selectivity effect also emerged, $F(2,148) = 3.74$, $p = .001$. The significant interaction effect of condition and Selectivity has been discussed previously. The power of α as a predictor of recall, thus, generally supports the earlier results concerning the Object Location Task and the Tower separately. In summary, the analyses with selectivity as a covariate show that when individual differences in spontaneous selectivity have been accounted for, the spatial location memory composite (α) predicts differences in selective recall. The span composite composed of Forward Digit Span and Word Span scores (β) predicts differences in selective recall only for those children who spontaneously produce and execute the selective strategy, however.

Finally, the overall memory capacity composite, Total Capacity, was entered as a predictor of selective recall. Total Capacity was entered into a regression model as a continuous independent variable along with Selectivity as a covariable and the within-subjects categorical variable of condition (3). Significant interaction effects were indicated between Total Capacity and Selectivity, $F(1,40) = 4.11$, $p = .05$, and between condition and Selectivity, $F(1,160) = 7.07$, $p < .001$.

The significant interaction of interest, that between Total Capacity and Selectivity, was clarified by entering Total Capacity as a continuous independent variable into separate regression models for consistently selective and less selective children in order to predict selective recall. (Note: Consistently selective children were at least 70% selective on both trials in the Spontaneous condition.) Condition (3) was again entered into each model as a categorical independent variable with repeated measures. Total Capacity significantly predicted selective recall for consistently selective children, $F(1,40) = 8.80$, $p < .01$, but not for the less selective children. The significant effect of Total Capacity only for consistently selective children is assumed to largely reflect the previous finding that S (the composite of Forward Digit Span and Word Span scores) was predictive of selective recall only for consistently selective children.

CHAPTER IV DISCUSSION

Summary of Results

It was hypothesized that individual differences in short-term memory capacity would predict recall in the selective attention task. There was support for this, but with important qualifications. In general, the two spatial location capacity measures, Mr. Deneubourg and the Objects Location task, predicted selective recall both as individual measures and when combined as a composite. Additionally, both Forward Right Span alone and the memory capacity composite constructed from Forward Right Span and Word Span scores predicted selective recall for those children who were consistently selective on the Spontaneous trials but not for those children who were less selective. Performance on the Backward Right Span was not a significant predictor.

One of the two significantly predictive memory capacity measures predicted selective recall differentially according to the effortfulness of strategy use. More specifically, Mr. Deneubourg scores predicted selective recall only in one condition--the condition in which the effort required to produce and execute the selection strategy was the greatest--the Spontaneous condition. In general, selectivity

In this condition (the baseline condition) was fairly high--77% of the four spaced covered relevant objects (distance = 100). One half of the children (42 subjects) were consistently selective--at least 75% selective on both of the spontaneous trials. Nevertheless, as expected from previous research, recall in this baseline condition was low to moderate--a mean of 2.87 (out of 4 possible) object locations were recalled on each trial.

Contrary to predictions, children with high memory capacity did not produce the selective strategy on the spontaneous trials more often than those with low capacity. However, memory capacity was not predictive of the overall type of strategy used (i.e., consistently selective, consistently spatial, partially strategic, or other, unidentifiable pattern of strategy use) on the baseline spontaneous trials.

Finally, overall consistency across the five different short-term memory capacity measures was not revealed. Performances on the Forward Digit Span and Word Span were positively related as were performances on the Object Locations task and Wt. Considered performances on the Backward Digit Span revealed no clear pattern of relations with any of the other memory capacity measures when examined across the two studies.

Memory Capacity as a Predictor of Selective Recall

Frederley, Garfield-Hall, Means, and Schneider (1987) found that individual differences in memory capacity affect prediction only when strategy use occurs, but is effortful. Thus, the hypotheses of the present study were contingent on the level of selectivity actually obtained on the spontaneous trials. The children in the present study were fairly selective, but not near ceiling, in the spontaneous condition (where the effort of producing and executing the selective strategy was greatest). This outcome suggests that although executing the selective strategy is within the capacity limitations of children of this age, it is yet still effortful. Thus, memory capacity should predict recall on the spontaneous trials. This moderately high selectivity is also important to note, because it had been hypothesized that prediction would be best in the Child Open condition only if the degree of selectivity was low on the spontaneous trials.

The hypothesis generated from the Frederley, Garfield-Hall, Means, and Schneider pattern of results was supported by one of the two capacity measures that were significant predictors. Mr. Garfield across predicted selective recall in the spontaneous condition but not in either the Child Open condition (when the effort of executing the selective strategy was removed) or the Adult Open condition (when the effort of both executing and executing the selective

strategy was reversed). Thus, when the hypothesized interaction between capacity and condition did occur (for the EC Condition task), it indicated that prediction was best in the most effortful condition--the Spontaneous condition, as expected. The lack of prediction in the Child Open and Adult Open conditions was not due to ceiling effects in recall or reduced variability in either of these two conditions. The mean recall in the Child Open and Adult Open conditions was 3.75 and 4.25 (out of 6 possible), respectively, and the standard deviations were similar in the three conditions.

The finding that individual differences on the Objects Location task were predictive of selective recall across all conditions did not fit the expected pattern described above. The children with greater capacity had greater recall, regardless of how effortful their strategy production. It may be relevant that this capacity measure was the one most similar to the three recall conditions with respect to stimulus layout and instructions.

Of the three memory capacity composites, the EC composite (Objects Location and EC Condition) surfaced as the best overall predictor of selective recall. It should be noted that both the Objects Location and EC Condition tasks measured memory-for-locations--the same type of recall required on the selective attention task.

One interesting finding was that the memory capacity composite constructed from scores on the forward digit span and word span (2) predicted selective recall only for those children who spontaneously exhibited consistent use of the selective strategy. Although the two spatial location capacity measures (Objects Location and 8r. Overlap) were predictive of selective recall in general, neither measure differentially predicted selective recall for those children who consistently produced the selective strategy and those who did not. There are several possible interpretations of this pattern of results.

First, one possible interpretation focuses on Beyer and Reis's (1979) two-stage model of performance on selective attention tasks and proposes that the span composite is especially important for selective children in the second stage. Beyer and Reis suggest that, in the first stage, individuals must discriminate between relevant and irrelevant stimuli. With the present task this would be the equivalent of choosing which doors to open (i.e., type of strategy used on the spontaneous trials). As described above, differences in capacity apparently do not affect this first stage. By definition, the selective children have achieved this first stage. The second stage of the model involves further cognitive processing of the information, once the relevant objects have been selected. Processing in this stage would include activities such as rehearsing or

imagery the objects to aid subsequent selective recall. The pattern of results may indicate the sensitivity of Forward Digit Span and Word Span to prediction in this second stage of Rogers and Hale's model. These two measures should be more predictive than the other capacity measures, of facility with the type of recall required in the second stage of performance on the Miller and Weiss task. Both are dependent upon verbal processing abilities--the same type of abilities that would most likely be required in a verbal rehearsal strategy in this second stage. Additionally, Forward Digit Span, which was more predictive than Word Span, may tap tapping for serial recall (i.e., order of the items is important), an ability that is relevant for the selective recall task. This type of serial recall on both the Forward Digit Span and the Miller and Weiss task could conceivably be due either perceptual or verbal representations of the information. Therefore, increased capacity on the Forward Digit Span task could be predictive of selective recall even for those children not employing in some form of verbal rehearsal.

How likely is it that children of this age would be attempting the use of verbal rehearsal strategies on this task? It is generally assumed that prior to 6 or 7 years of age children do not use rehearsal strategies spontaneously on memory tasks (and this rehearsal is infrequent even at 6 or 7 years of age). Garry (1973), however, reported

significant amounts of subvocalization in 4- and 5-year-olds during both picture presentation and a pretest delay period in a memory task. The amount of subvocalization was significantly, positively related to recall. Thus, young children use rehearsal and it helps their recall. Furthermore, younger and less bright children subvocalized less than older and intellectually brighter children during the delay period. Like the brighter children in the Savary study, children with high memory capacity on Forward Digit Span and Word Span may attempt the use of rehearsal techniques more often. This could be due to their increased ability to process and store verbally encoded information. In addition, low capacity children may not rehearse because that strategy is effortful. Siegler (1984) has suggested that in problem solving tasks which involve "rule" approaches, children tend to "fall back" to less demanding rules for task solution if the more advanced, efficient rule is too effortful and the likelihood of success using that rule is less certain. The low capacity children may have been forced to do this.

A final version of this final interpretation based on the knowledge model concerns subvocalization. Children who have higher memory capacity on these measures may tend to use rehearsal more often due to an increased awareness of the need to use a mnemonic strategy. Awareness that strategy use facilitates recall is related to the tendency to use a

strategy (Feldman & Neuse, 1984). However, Case (1985) suggests that individual children can differ from each other on particular classes of tasks due not only to differences in the efficiency of their domain-specific operations, but also to differences in the efficiency of regulatory sub-processes that lead to hierarchical integration of selected mental structures. One such sub-process is evaluation of the mental operations generated to reach a particular goal, to determine whether or not they achieve the desired goal. In arriving at such a decision, the child must determine the functional utility of the mental operations performed. Depending on the outcome of this evaluation, the child may alter the sequence and type of mental operations engaged in to more successfully obtain the task goal. On the Miller and Weine task, perhaps some of the children with higher memory capacity or Forward Digit Span and Word Span are more efficient evaluators of their cognitive operations and subsequently become more aware of the need to use some type of labeling or rehearsal strategy to aid selective recall. Individual differences in the use of regulatory sub-processes such as evaluation according to Case (1985), may result from either biological or cultural/experiential factors.

A second interpretation of why the 4 capacity composite predicts recall for the selective children again focuses on Blynn and Pitt's tripartite model. However, it places more

emphasis on processing in the first stage. The effort of producing and executing the selective strategy may require as much capacity for generalization users that too little capacity remains to devote either to short-term storage of the locations of relevant objects or to further memory processing (e.g., rehearsal) and subsequent storage of relevant information. Therefore, capacity should predict selective recall only for those children who have automatized use of the selective strategy to some greater degree. For example, Case (1984) suggests that as information processing becomes increasingly automatic, less operating space is required. Therefore, capacity is freed up which can then be devoted to short-term storage of the information. Studies by both Gatherer (1984) and Bjorklund and Harshbarger (1987) described in the Introduction support such an interpretation. If this were the case in the present study then memory capacity should have predicted selective recall at least moderately for the less selective children when the effort of either accessing or accessing and executing the selective strategy was removed (i.e., the Cold Space and Adult Space conditions, respectively). The lack of an interaction between memory capacity and condition for less selective children fails to support such an interpretation. Furthermore, this interpretation which focuses on the effortfulness of accessing and executing the appropriate strategy offers no explanation of why the

interaction between memory capacity and selectivity resulted only for the 2 memory capacity composite (i.e., Forward Digit Span and Word Span).

3. What possible interpretation of the interaction between the 3 capacity composite and selectivity focuses on the range and variability of selective recall for less selective children. If the range and variability of selective recall were much smaller for less selective children, then a relationship between memory capacity and selective recall would have been almost impossible to detect. Otherwise, perhaps the 3 capacity composite could have predicted selective recall for the entire sample again. However, when the data for the consistently selective versus less selective children are analyzed, such an interpretation is not viable.

Memory Capacity as a Predictor of Spontaneous Recency Set

Contrary to prediction, children with high memory capacity were not spontaneously more selective than those children with low memory capacity. Memory capacity, in general, was not significantly related to overall type of spontaneous strategy use. Although children who used different types of spontaneous strategies did not differ significantly with regard to memory capacity, a trend was noted in that children with high memory capacity often used a consistently spatial (row by row) pattern of spelling

domain. One can speculate about the possible reasons for why high capacity children would not necessarily use an efficient pattern of attending.

According to a developmental lag hypothesis, younger and less bright children often exhibit patterns of responding that are less efficient than those of older and more intelligent children. However, this line of reasoning is contrary to the trend observed in the present study. Although selectivity was fairly high overall, the children with higher memory capacity often tended to use a developmentally earlier pattern of attending. Therefore, other possible reasons may need to be considered to explain the trend noted. Several suggestions will be made concerning not only memory capacity but other individual differences variables which may have affected performance on the Miller and Weiss selective attention task.

First, those children who had high memory capacity on the spatial location tasks (Objects Location and Mr. Gumbach) may have approached the selective attention task, in general, and selective recall, specifically, as a perceptual organization task. These children demonstrated a greater degree of efficiency in recalling the locations of specific bits of information embedded in an overall perceptual array of the two spatial locations equally measures. (Recall that the Objects Location measure and Mr. Gumbach emerged as significant main effects and did not interact with

selectivity in the prediction of selective recall. Because they were more efficient at processing this type of information, these children may have relied more strongly on this ability in guiding their attention and selective recall in the Miller and Weir task. It follows, therefore, that these children might, thus, open all doors in an organized and efficient, though demanding, search pattern and then depend on their generally good spatial location recall abilities to recall the relative positions of relevant stimuli.

Another possible explanation of the lack of a tendency for children with high memory capacity to use a selective pattern of attending focuses on the substitution of effort in this information-processing task. It has been suggested that the effortfulness of strategy use will determine a child's tendency to employ that particular strategy (e.g., Kover, 1984). Thus, the children with high memory capacity should have been the children most likely to use the effortful selective strategy. Children with lower capacity would have been expected to use the less effortful spatial strategy. This formed the basis for the prediction in this study that individual differences in memory capacity would be related to the steps of strategy use noted by Miller et al. (1988). In contrast, however, Bialison and Jeffrey (1978) suggest that individual processing styles may override the influence of the effort requirement. That is,

they propose that the amount of effort expended may be a function of the requirements of the information-processing strategy the child tends to employ. Thus, the child may tend to use a certain type of attentional strategy, such as an exhaustive search strategy, regardless of the effortfulness of a more appropriate selective strategy. This general tendency (individual style of processing) would then determine how the child utilized his attentional efforts, rather than the effortfulness of a certain appropriate strategy determining the child's strategic tendency.

Another important factor would be that many of the high-ability children may have adopted an organized, exhaustive search strategy (such as opening all doors in a spatial pattern) due to a lack of specific experience on this task--experience that would enable them to adopt strategic patterns of responding to the task demands. Pressing, Bickowski, and Schneider (1987) suggest that the knowledge of how, when, and where to apply each of various strategies/techniques is one component of good strategy use. A lack of experience on the present experimental task would preclude such knowledge on the part of the children and predispose them to use the general, exhaustive search strategy rather than the more specific strategy of opening only relevant doors. This may have been the case even though use of the selective strategy probably would not have been too effortful for these children (as evidenced by the fact

amount of selectivity overall in the spontaneous condition, in addition to the high capacity scores of these children. The knowledge of many strategies that can be tapped, some general and some specific, but all useful for obtaining goals is another component of good strategy use in the Pressley, Borkowski, and Schneider (1987) model. Perhaps if the high capacity children had been given more than two trials in the spontaneous strategy phase of the study, their superior capacity would have profited from the experience with the task.

Additional individual differences variables that could account for high capacity children's failure to draw on this capacity in the Miller and Weir task include motivational, cognitive and metacognitive factors (see Schneider & Jeffrey, 1975). One such variable is the child's causal attribution of success and failure in problem-solving situations. Pressley, Borkowski, and Schneider (1987) suggest that a general understanding that good performance is tied to effort is another main component of good strategy use. A child who attributes successes and failures to luck or circumstances beyond his control is less likely to engage in effortful strategic behavior regardless of his capabilities. Therefore, on the Miller and Weir task such a child may exhibit a less effortful, spotted pattern of attending as well as a nonstrategic sequence of busy openings.

Another variable that could account for differences in patterns of attention is the child's estimation of task difficulty. The assessment of task difficulty is often referred to as a metacognitive process (e.g., Brown, 1978, 1977; Flavell, Brainerd, & Byrk, 1978; Brainerd, Leonard, & Flavell, 1978). A child who underestimates the difficulty of the selective attention task might be more likely to engage in a less selective, more spatial, pattern of attention if he does not realize that the number of objects viewed would exceed his memory capacity. A child who overestimated the difficulty of the task from the outset would perhaps be more selective in order not to exceed the limitations of his memory capacity. Again, more trials might have provided more feedback regarding task difficulty and have revealed an effect of capacity.

In conclusion, the above suggestions regarding individual differences in spontaneous strategy use might be examined more fruitfully within an experimental design that includes a greater number of baseline trials. In this way, a more reliable measure of strategy use and/or an observation of the direction of change in strategy use as a result of experience could be obtained. The present study was not designed to provide such a detailed examination of these issues.

Consistency among Memory Capacity Measures

Cass (1985) suggests that there should be moderate consistency among measures of short-term memory capacity. The measures would not be expected to be highly, positively correlated due to differences in the specificity of mental operations required by the various tasks (e.g., the processing of auditory verbal input versus visual, spatial location information). That is, some degree of specificity is expected. On the other hand, intercorrelations would not be expected to be zero or near zero, either. An individual who has a larger short-term memory capacity should have a processing advantage over a person with a smaller capacity regardless of the nature of the measurement task (since there is always a trade-off between processing and storage space).

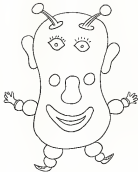
In the present study, when correlations between capacity measures were examined both across grades and within each grade, a pattern began to emerge. Those capacity measures that mentally required the processing of similar types of information appeared to yield the most consistent measurements. Forward Digit Span and Word Span both require memory for verbal input and were significantly, positively correlated ($r = .59$, $p < .000$). The tasks differed, however, with respect to the type of verbal recall required (e.g., memory for digits versus words) and the necessity for verbal recall (required only for Forward Digit Span). The Objects

Locations task and Mr. Sumner both required recall of spatial location information and were moderately, positively correlated ($r = .42$, $p < .001$). The Object Locations task, however, may have also encouraged verbal processing due to the array design. This may have weakened the correlation between performances on the two spatial location measures. Backward Digit Span did not appear to be consistently related to any of the other capacity measures. Also, this measure had the smallest variance of the five measures, which could have worked against obtaining relationships. Still, the Forward Digit Span task also had a low variance, but entered into significant relationships. It should be noted that Backward Digit Span was the only task which required reordering of information prior to responding.

A more positive view of the consistency among the capacity measures emerges when one notes that, overall (across both grades), each capacity measure was significantly, positively correlated with at least two other capacity measures. Dempster (1985) suggests that weak correlations involving measures of short-term memory capacity may result from the low measurement levels and subsequent low reliabilities. Future research addressing the issue of consistency among measures of short-term memory (only a minor focus of the present study) may yield more conclusive findings by obtaining measures of same performance over an increased number of trials.

The present study suggests that a moderate degree of consistency does exist among measures of short-term memory capacity, and that individual differences in short-term memory capacity can be used to predict the facilitative effects of strategy use. A more refined view of the role of effort in strategy use and recall comes from examining both overall capacity and subunits of capacity, as in the present study.

APPENDIX
REL. COLUMBIA



REFERENCES

- Miller-Ward, L., Gewirtz, P. A., & Eichen, D. C. (1984). The expression of association in early childhood. *Journal of Experimental Child Psychology*, 37, 548-574.
- Wjcklund, D. P., & Marshulaker, K. E. (1982). Developmental differences in the medial effect requirements of an organizational strategy in free recall. *Journal of Experimental Child Psychology*, 34, 308-325.
- Wassard, C. J. (1982). Working-memory systems and cognitive development. In R. J. Glaser (Ed.), *Recent advances in cognitive developmental theory: Progress in cognitive developmental research* (pp. 147-154). New York: Springer-Verlag.
- Wassard, C. J., & Klinger, J. (1985). On the independence of short-term memory and working memory in cognitive development. *Cognitive Psychology*, 17, 300-347.
- Brown, A. L. (1979). The development of memory, knowing, knowing about knowing, and knowing how to know. In A. G. Evans (Ed.), *Advances in child development and behavior* (Vol. 12). New York: Academic Press.
- Brown, A. L. (1977). Development, schooling, and the acquisition of knowledge about knowledge. In R. G. Anderson, E. J. Spino, & W. K. Wickens (Eds.), *School and the acquisition of knowledge*. Hillsdale, NJ: Lawrence Erlbaum.
- Gale, S. (1948). *Intellectual development: Birth to adulthood*. Chicago: Rand McNally.
- Geary, W., & Carpenter, P. A. (1980). Individual differences in working memory and counting. *Journal of Mental Sciences and Social Sciences*, 12, 400-414.
- Guy, M. C., & Scott, C. A. (1980). Children's use of perceptual set. *Journal of Experimental Child Psychology*, 29, 438-448.

- DeRosier-Decker, E., & Miller, P. E. (in press). The development of children's strategies for selective attention: Evidence for a transitional period. *Child Development*.
- Compton, P. S. (1981). Memory span: Sources of individual and developmental differences. *Psychological Bulletin*, 89, 83-100.
- Compton, P. S. (1985). Short-term memory development in childhood and adolescence. In C. J. Brainerd & M. Fox (Eds.), *Basic mechanisms in memory development: Processes in developing development* (pp. 187-220). New York: Springer-Verlag.
- Fabrizio, M. P., & Bopp, J. W. (1988). Use of verbal attributions about recall performance to assess strategy and predict strategic memory behavior in young children. *Developmental Psychology*, 24, 775-787.
- Flewell, J. E. (1979). Developmental studies of mediated memory. In M. W. Eysenck & L. F. Berman (Eds.), *Advances in child development and behavior* (Vol. 5, pp. 181-211). New York: Academic Press.
- Flewell, J. E., Feinshtein, A. E., & Bopp, J. J. (1980). Developmental changes in nonverbal memory. *Developmental Psychology*, 1, 134-140.
- Garcia, L. L. (1973). An audiocassette-tape study of natural speech and recall in preschool children. *Developmental Psychology*, 11(2), 274-281.
- Gibson, E. (1964). The natural effect requirement of manipulative response: A developmental study. *Journal of Experimental Child Psychology*, 20, 92-104.
- Hayes, J. W., & Kail, D. B. (1975). The development of attention in children. In E. B. Fitts (Ed.), *Minnesota symposium on child psychology* (Vol. 5, pp. 127-140). Minneapolis: University of Minnesota Press.
- Hayes, J. W., & Stansbury, E. E. (1977). Memory strategies of acquisition. In E. B. Fitts & J. W. Hayes (Eds.), *Perceptions on the development of memory and acquisition*. Hillsdale, NJ: Lawrence Erlbaum.
- Howell, E. V., & Guidic, E. E. (1978). Reflections on encoding and memory: An analysis of various attention by kindergarten children. *Journal of Experimental Child Psychology*, 25, 87-95.

- Keebler, D. G., & Smith, E. A. (1978). Is there a developmental trend from integrality to separability in perception? *Journal of Experimental Child Psychology*, 25, 448-500.
- Klogg, S. T., Marchione, E. A., & Lester, P. L. (1982). Short-term memory load and memory the "working memory" of information processing. *Journal of Experimental Psychology General*, 112, 190-195.
- Kroemer, M. A., Leonard, C., & Flavell, J. H. (1978). An intensive study of children's knowledge about memory. *Monographs of the Society for Research in Child Development*, 43(1, Serial No. 159).
- Lane, P. M., & Farnham, F. A. (1981). The development of selective attention. *Merrill-Palmer Quarterly*, 28, 317-327.
- McCarthy Scales of Children's Abilities. New York: The Psychological Corporation, 1972.
- Miller, P. H., & Scoville, T. E. (in press). Preschoolers' strategies of attention on a nondifferent task. *Developmental Psychology*.
- Miller, P. H., Baynes, P., Dennis-Davies, C., & Mudge-Kenny, J. (1979). Children's strategies for gathering information in three tasks. *Child Development*, 52, 1435-1438.
- Miller, P. H., & Nelson, M. B. (1980). Children's attention allocation, understanding of attention, and performance on the incidental learning task. *Child Development*, 52, 1187-1198.
- Nelson, P. H., Mundy-Kenny, J., & Aloise, P. (Strategies of selective attention: The role of effort.) Unpublished raw data.
- Rick, A. B., & Freedel, R. M. (1972). A study of strategies of visual attention in children. *Developmental Psychology*, 8, 148-157.
- Pressing, S., Rogoswki, J. C., & Schneider, W. (1987). Cognitive strategies Used strategy used coordinate determination and knowledge. In E. Yoon (Ed.), *Journal of Child Development* (Vol. 4). Greenwich, CN: JAI Press.
- Pressing, S., Ogilvie-Hall, T., Davis, S., & Schneider, W. (1987). Short-term memory, verbal competence, and eye as predictors of inquiry instructional effectiveness. *Journal of Experimental Child Psychology*, 43, 194-201.

- Shaywitz, A. J., & Spear, R. B. (1964). Selective attention and the processing of integrated and nonintegrated information: A developmental study. *Journal of Experimental Child Psychology*, 21, 73-85.
- Shiffrin, R. M. (1970). Capacity limitations in information processing, attention, and memory. In W. E. Koster (Ed.), *Handbook of learning and cognitive processes* (Vol. 2, pp. 173-206). Hillsdale, NJ: Lawrence Erlbaum.
- Sinclair, R. E. (1961). Developmental sequences within and between concepts. *Monographs of the Society for Research in Child Development*, 26, Serial 84, 127.
- Smith, L. B., & Ransell, D. G. (1977). Developmental trends in form classification: Evidence for a new reorganization of perceptual development. *Journal of Experimental Child Psychology*, 25, 174-190.
- Smith, L. B., Ransell, D. G., & Ransell, J. (1978). Developmental trends in voluntary selection attention: Differential effects of source distinctiveness. *Journal of Experimental Child Psychology*, 26, 465-485.
- Stanford-Binet Intelligence Scales. Fourth Edition. Chicago: The Riverside Publishing Company, 1970.
- Strett, D. F., Anderson, D. E., & Hall, A. D. (1970). A developmental study of the effects of irrelevant information on speeded classification. *Journal of Experimental Child Psychology*, 20, 117-135.
- Stanford-Binet Intelligence Scales for Children-Revised. New York: The Psychological Corporation, 1974.
- Woolf-Samoy, J., & Miller, P. (in press). The facilitation of selective attention in preschoolers. *Child Development*.
- Wolman, T., & Jeffrey, W. E. (1970). Attention and cognitive style in children. In S. A. Belsky & M. Lewis (Eds.), *Attention and cognitive development* (pp. 173-194). New York: Plenum Press.

BIOGRAPHICAL SKETCH

Janet Lynn Moody-Kennedy began her college years in Columbia, Tennessee, at Columbia State Community College. After receiving her Bachelor of Arts degree in 1968, she attended Memphis State University where she received her Bachelor of Arts degree in psychology in 1970. The author worked for the Tennessee Department of Human Services as an investigator and counselor of child abuse and neglect before beginning graduate school in 1971. Janet attended the University of Florida as a graduate student in developmental psychology from 1971 to 1978. At the time of this writing, she holds a master's degree in August of 1980.

Janet has accepted a position as Assistant Professor of Psychology at Eastern University in Greenville, South Carolina, to begin in the fall of 1980. She will be the department's first developmental psychologist and is eager to begin a career of teaching and research.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy


Barbara K. Miller, Chairperson
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy


Scott A. Miller
Associate Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy


Lisa A. Pincus
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy


Richard A. Brown
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Joseph J. Kilgus
Joseph J. Kilgus
Professor of Foundations of
Education

This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 1968

Dean, Graduate School